List of processes and associated names in bio_BioEBUS.F routine

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Light and Temperature limitation

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Light limitation for SPhy growth ([ ]): NFlux_lightlimitP1
Light limitation for LPhy growth ([ ]): NFlux_lightlimitP2

Temperature limitation for SPhy growth ([d^{-1}]): NFlux_templimitP1
Temperature limitation for LPhy growth ([d^{-1}]): NFlux_templimitP2

Nutrient limitation

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NO_3^- limitation for SPhy growth ([ ]): NFlux_NO3limitP1
NO_2^- limitation for SPhy growth ([ ]): NFlux_NO2limitP1
NH_4^+ limitation for SPhy growth ([ ]): NFlux_NH4limitP1

NO_3^- limitation for LPhy growth ([ ]): NFlux_NO3limitP2
NO_2^- limitation for LPhy growth ([ ]): NFlux_NO2limitP2
NH_4^+ limitation for LPhy growth ([ ]): NFlux_NH4limitP2

Nutrient limitation for SPhy growth ([ ]) =
NFlux_NO3limitP1+NFlux_NO2limitP1+NFlux_NH4limitP1
Nutrient limitation for LPhy growth ([ ]) =
NFlux_NO3limitP2+NFlux_NO2limitP2+NFlux_NH4limitP2

NO_3^- uptake by SPhy and exudation

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Assimilation of NO_3^- by SPhy ([mmolN/m^3/s]): NFlux_NewProdNO3P1
Net assimilation ([mmolN/m^3/s]): NFlux_NewProdNO3P1*(1.-epsilon1)
Exudation of SPhy to DON ([mmolN/m^3/s]): NFlux_NewProdNO3P1*epsilon1
Production of O_2 by SPhy ([mmolO_2/m^3/s]): NFlux_NewProdNO3P1*ro2n

NFlux_NewProdNO3P1 ([mmolN/m^3/s]) =
NFlux_lightlimitP1*NFlux_templimitP1*NFlux_NO3limitP1*SPhy/(24.*3600.)

NO_3^- uptake by LPhy and exudation

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Assimilation of NO_3^- by LPhy ([mmolN/m^3/s]): NFlux_NewProdNO3P2
Net assimilation ([mmolN/m^3/s]): NFlux_NewProdNO3P2*(1.-epsilon2)
Exudation of LPhy to DON([mmolN/m^3/s]): NFlux_NewProdNO3P2*epsilon2
Production of O_2 by LPhy ([mmolO_2/m^3/s]): NFlux_NewProdNO3P2*ro2n

NFlux_NewProdNO3P2 ([mmolN/m^3/s]) =
Flux_lightlimitP2*NFlux_templimitP2*NFlux_NO3limitP2*LPhy/(24.*3600.)

NO_2^- uptake by SPhy and exudation

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Assimilation of NO_2^- by SPhy ([mmolN/m^3/s]): NFlux_NewProdNO2P1
Net assimilation ([mmolN/m^3/s]): NFlux_NewProdNO2P1*(1.-epsilon1)
Exudation of SPhy to DON ([mmolN/m^3/s]): NFlux_NewProdNO2P1*epsilon1
Production of O_2 by SPhy ([mmolN/m^3/s]): NFlux_NewProdNO2P1*ro2n

NFlux_NewProdNO2P1 ([mmolN/m^3/s]) =
NFlux_lightlimitP1*NFlux_templimitP1*NFlux_NO2limitP1*SPhy/(24.*3600.)

NO_2^- uptake by LPhy and exudation

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Assimilation of NO_2^- by LPhy ([mmolN/m^3/s]): NFlux_NewProdNO2P2
Net assimilation ([mmolN/m^3/s]): NFlux_NewProdNO2P2*(1.-epsilon2)
Exudation of LPhy to DON ([mmolN/m^3/s]): NFlux_NewProdNO2P2*epsilon2
Production of O_2 by LPhy ([mmolO_2/m^3/s]): NFlux_NewProdNO2P2*ro2n

NFlux_NewProdNO2P2 ([mmolN/m^3/s]) =
NFlux_lightlimitP2*NFlux_templimitP2*NFlux_NO2limitP2*LPhy/(24.*3600.)

NH_4^+ uptake by SPhy and exudation

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Assimilation of NH_4^+ by SPhy ([mmolN/m^3/s]): NFlux_RegProdP1
Net assimilation ([mmolN/m^3/s]): NFlux_RegProdP1*(1.-epsilon1)
Exudation of SPhy to DON ([mmolN/m^3/s]): NFlux_RegProdP1*epsilon1
Production of O_2 by SPhy ([mmolO_2/m^3/s]):NFlux_RegProdP1*ro2n

NFlux_NewProdNH4P1 ([mmolN/m^3/s]) =
NFlux_lightlimitP1*NFlux_templimitP1*NFlux_NH4limitP1*SPhy/(24.*3600.)

NH_4^+ uptake by LPhy and exudation

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Assimilation of NH_4^+ by LPhy ([mmolN/m^3/s]): NFlux_RegProdP2
Net assimilation ([mmolN/m^3/s]): NFlux_RegProdP2*(1.-epsilon2)
Exudation of LPhy to DON ([mmolN/m^3/s]): NFlux_RegProdP2*epsilon2
Production of O_2 by LPhy ([mmolO_2/m^3/s]): NFlux_RegProdP2*ro2n

NFlux_NewProdNH4P2 ([mmolN/m^3/s]) =
NFlux_lightlimitP2*NFlux_templimitP2*NFlux_NH4limitP2*LPhy/(24.*3600.)

Primary Production ([mmolN/m^3/s]) =
(NFlux_NewProdNO3P1+NFlux_NewProdNO3P2+NFlux_NewProdNO2P1
+NFlux_NewProdNO2P2+NFlux_RegProdP1+NFlux_RegProdP2)

Nitrification of NH_4^+ ==> NO_2^- ==> NO_3^-

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Nitrification NH_4^+ to NO_2^- ([mmolN/m^3/s]): NFlux_Nitrif1

Nitrification NO_2^- to NO_3^- ([mmolN/m^3/s]): NFlux_Nitrif2

Consumption of O_2 during nitrification ([mmolO_2/m^3/s]) =

NFlux_Nitrif1*1.5+NFlux_Nitrif2*0.5

SPhy and LPhy grazing to SZoo and SDet
SPhy and LPhy mortality to SDet

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SPhy mortality to SDet ([mmolN/m^3/s]): NFlux_P1mort

LPhy mortality to SDet ([mmolN/m^3/s]): NFlux_P2mort

SPhy grazing by SZoo ([mmolN/m^3/s]): NFlux_P1Z1Grazing

LPhy grazing by SZoo ([mmolN/m^3/s]): NFlux_P2Z1Grazing

Assimilated grazing ([mmolN/m^3/s]):

(NFlux_P1Z1Grazing+NFlux_P2Z1Grazing)*beta1

Fecal pellets to SDet ([mmolN/m^3/s]):

(NFlux_P1Z1Grazing+NFlux_P2Z1Grazing)*(1.-beta1)

SPhy, LPhy and SZoo grazing to LZoo and LDet

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SPhy grazing by LZoo ([mmolN/m^3/s]): NFlux_P1Z2Grazing

LPhy grazing by LZoo ([mmolN/m^3/s]): NFlux_P2Z2Grazing

SZoo grazing by LZoo ([mmolN/m^3/s]): NFlux_Z1Z2Grazing

Assimilated grazing ([mmolN/m^3/s]):

(NFlux_P1Z2Grazing+NFlux_P2Z2Grazing+NFlux_Z1Z2Grazing)*beta2

Fecal pellets to LDet ([mmolN/m^3/s]):

(NFlux_P1Z2Grazing+NFlux_P2Z2Grazing+NFlux_Z1Z2Grazing)*(1.-beta2)

SZoo excretion to NH_4^+ and DON
SZoo mortality to SDet

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Mortality of SZoo ([mmolN/m^3/s]): NFlux_Z1mort

Exretion of SZoo ([mmolN/m^3/s]): NFlux_Z1metab

Inorganic excretion ([mmolN/m^3/s]): NFlux_Z1metab*f2_Z1_NH4

Organic excretion ([mmolN/m^3/s]): NFlux_Z1metab*(1.-f2_Z1_NH4)

Consumption of O_2 due to Szoo excretion ([mmolO_2/m^3/s]):

NFlux_Z1metab*ro2n*f2_Z1_NH4

LZoo excretion to NH_4^+ and DON
LZoo mortality to LDet

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Mortality of LZoo ([mmolN/m^3/s]): NFlux_Z2mort
Exretion of LZoo ([mmolN/m^3/s]): NFlux_Z2metab
Inorganic excretion ([mmolN/m^3/s]): NFlux_Z2metab*f2_Z2_NH4
Organic excretion ([mmolN/m^3/s]): NFlux_Z2metab*(1.-f2_Z2_NH4)
Consumption of O_2 due to LZoo excretion ([mmolO_2/m^3/s]):
NFlux_Z2metab*ro2n*f2_Z2_NH4

Remineralization of SDet, LDet and DON to NH_4^+
Oxic remineralization and denitrification (Yakushev et al, 2007)
Hydrolysis of SDet and LDet to DON

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Hydrolysis of SDet ([mmolN/m^3/s]): NFlux_HydrolD1
Oxic remineralization of SDet ([mmolN/m^3/s]): NFlux_ReminOxyD1
1st stage of denitrification of SDet ([mmolN/m^3/s]): NFlux_Denitr1D1
2nd stage of denitrification of SDet ([mmolN/m^3/s]): NFlux_Denitr2D1

Hydrolysis of LDet ([mmolN/m^3/s]): NFlux_HydrolD2
Oxic remineralization of LDet ([mmolN/m^3/s]): NFlux_ReminOxyD2
1st stage of denitrification of LDet ([mmolN/m^3/s]): NFlux_Denitr1D2
2nd stage of denitrification of LDet ([mmolN/m^3/s]): NFlux_Denitr2D2

Oxic remineralization of DON ([mmolN/m^3/s]): NFlux_ReminOxyDON
1st stage of denitrification of DON ([mmolN/m^3/s]): NFlux_Denitr1DON
2nd stage of denitrification of DON ([mmolN/m^3/s]): NFlux_Denitr2DON

Total remineralization of SDet ([mmolN/m^3/s]):
NFlux_ReminOxyD1+NFlux_Denitr1D1+NFlux_Denitr2D1
Total remineralization of LDet ([mmolN/m^3/s]):
NFlux_ReminOxyD2+NFlux_Denitr1D2+NFlux_Denitr2D2
Total remineralization of DON ([mmolN/m^3/s]):
NFlux_ReminOxyDON+NFlux_Denitr1DON+NFlux_Denitr2DON

NO_3^- consumption during 1st stage of denitrification of SDet ([mmolN/m^3/s]):
NFlux_Denitr1D1/0.5
NO_3^- consumption during 1st stage of denitrification of LDet ([mmolN/m^3/s]):
NFlux_Denitr1D2/0.5
NO_3^- consumption during 1st stage of denitrification of DON ([mmolN/m^3/s]):
NFlux_Denitr1DON/0.5

NO_2^- consumption during 2nd stage of denitrification of SDet ([mmolN/m^3/s]):
NFlux_Denitr2D1/0.75
NO_2^- consumption during 2nd stage of denitrification of LDet ([mmolN/m^3/s]):
NFlux_Denitr2D2/0.75
NO_2^- consumption during 2nd stage of denitrification of DON ([mmolN/m^3/s]):
NFlux_Denitr2DON/0.75

NO_3^- consumption during 1st stage of denitrification ([mmolN/m^3/s]):
(NFlux_Denitr1D1+NFlux_Denitr1D2+NFlux_Denitr1DON)/0.5
NO_2^- consumption during 2nd stage of denitrification ([mmolN/m^3/s]):
(NFlux_Denitr2D1+NFlux_Denitr2D2+NFlux_Denitr2DON)/0.75

O_2 consuption for SDet remineralization ([mmolO_2/m^3/s]): NFlux_ReminOxyD1*ro2n
O_2 consuption for LDet remineralization ([mmolO_2/m^3/s]): Flux_ReminOxyD2*ro2n
O_2 consuption for DON remineralization ([mmolO_2/m^3/s]): NFlux_ReminOxyDON*ro2n

Anammox

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NO_2^- consumption by anammox ([mmolN/m^3/s]): NFlux_NO2anammox
NH_4^+ consumption by anammox ([mmolN/m^3/s]): NFlux_NH4anammox

O_2 Flux at ocean-atmosphere interface

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O_2 flux at ocean-atmosphere interface ([mmolO_2/m^3/s]): O2Flux_GasExc
(positive if ocean takes up O_2 from the atmosphere)

Parametrisation for N_2O production: Suntharalingam et al. (2000, 2012)

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N_2O production ([mmolN_2O/m^3/s]): NFlux_paramN2O

N_2O Flux at ocean-atmosphere interface

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N_2O flux at ocean-atmosphere interface ([mmolN_2O/m^3/s]): N2OFlux_GasExc
(positive if ocean takes up N_2O from the atmosphere)

Vertical sinking flux

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LPhy vertical sinking ([mmolN/m^3/s]): NFlux_VSinkP2
SDet vertical sinking ([mmolN/m^3/s]): NFlux_VSinkD1
LDet vertical sinking ([mmolN/m^3/s]): NFlux_VSinkD2

Source-minus-sink (SMS) terms of state variables

$SMS(NO_3^-)$ = - (NFlux_NewProdNO3P1 + NFlux_NewProdNO3P2) + NFlux_Nitrif2
- (NFlux_Denitr1D1 + NFlux_Denitr1D2 + NFlux_Denitr1DON)/0.5

$SMS(NO_2^-)$ = - (NFlux_NewProdNO2P1 + NFlux_NewProdNO2P2)
+ NFlux_Nitrif1 - NFlux_Nitrif2
+ (NFlux_Denitr1D1 + NFlux_Denitr1D2 + NFlux_Denitr1DON)/0.5
- (NFlux_Denitr2D1 + NFlux_Denitr2D2 + NFlux_Denitr2DON)/0.75
- NFlux_NO2anammox

$SMS(NH_4^+)$ = - (NFlux_RegProdP1 + NFlux_RegProdP2) - NFlux_Nitrif1
+ f2_Z1_NH4*NFlux_Z1metab + f2_Z2_NH4*NFlux_Z2metab
+ NFlux_ReminOxyD1 + NFlux_ReminOxyD2 + NFlux_ReminOxyDON
+ NFlux_Denitr1D1 + NFlux_Denitr1D2 + NFlux_Denitr1DON
+ NFlux_Denitr2D1 + NFlux_Denitr2D2 + NFlux_Denitr2DON
- NFlux_NH4anammox

SMS(SPhy) = (1.-epsilon1)*(NFlux_NewProdNO3P1 + NFlux_NewProdNO2P1
+ NFlux_RegProdP1)
- (NFlux_P1Z1Grazing + NFlux_P1Z2Grazing)
- NFlux_P1mort

SMS(LPhy) = (1.-epsilon2)*(NFlux_NewProdNO3P2 + NFlux_NewProdNO2P2
+ NFlux_RegProdP2)
- (NFlux_P2Z1Grazing + NFlux_P2Z2Grazing)
- NFlux_P2mort
± Δ(NFlux_VSinkP2)

SMS(SZoo) = + beta1*(NFlux_P1Z1Grazing + NFlux_P2Z1Grazing) - NFlux_Z1Z2Grazing
- NFlux_Z1metab
- NFlux_Z1mort

SMS(LZoo) = + beta2*(NFlux_P1Z2Grazing + NFlux_P2Z2Grazing + NFlux_Z1Z2Grazing)
- NFlux_Z2metab
- NFlux_Z2mort

SMS(SDet) = + (1.-beta1)*(NFlux_P1Z1Grazing + NFlux_P2Z1Grazing)
+ NFlux_P1mort + NFlux_P2mort + NFlux_Z1mort
- NFlux_HydrolD1
- NFlux_ReminOxyD1
- (NFlux_Denitr1D1 + NFlux_Denitr2D1)
+ Δ(NFlux_VSinkD1)

SMS(LDet) = + (1.-beta2)*(NFlux_P1Z2Grazing + NFlux_P2Z2Grazing
+ NFlux_Z1Z2Grazing)
+ NFlux_Z2mort
- NFlux_HydrolD2
- NFlux_ReminOxyD2

- (NFlux_Denitr1D2 + NFlux_Denitr2D2)
+ Δ(NFlux_VSinkD2)

SMS(DON) = epsilon1*(NFlux_NewProdNO3P1 + NFlux_NewProdNO2P1
+ NFlux_RegProdP1)
+ epsilon2*(NFlux_NewProdNO3P2 + NFlux_NewProdNO2P2
+ NFlux_RegProdP2)
+ (1.-f2_Z1_NH4)*NFlux_Z1metab
+ (1.-f2_Z2_NH4)*NFlux_Z2metab
+ NFlux_HydrolD1 + NFlux_HydrolD2
- NFlux_ReminOxyDON
- (NFlux_Denitr1DON + NFlux_Denitr2DON)

SMS(total N) = SMS(NO_3^-) + SMS(NO_2^-) + SMS(NH_4^+) + SMS(SPhy) + SMS(LPhy) + SMS(SZoo) + SMSLZoo) + SMS(SDet) + SMS(LDet) + SMS(DON)

SMS(O_2) = ro2n*(NFlux_NewProdNO3P1 + NFlux_NewProdNO3P2
+ NFlux_NewProdNO2P1 + NFlux_NewProdNO2P2
+ NFlux_RegProdP1 + NFlux_RegProdP2
- f2_Z1_NH4*NFlux_Z1metab - f2_Z2_NH4*NFlux_Z2metab
- NFlux_ReminOxyD1 - NFlux_ReminOxyD2 - NFlux_ReminOxyDON)
- (NFlux_Nitrif1*1.5 + NFlux_Nitrif2*0.5)
+ O2Flux_GasExc

SMS(N_2O) = + NFlux_paramN2O + N2OFlux_GasExc
